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Regional and sectoral assessment on climate-change in Pakistan: Social norms and indigenous perceptions on climate-change adaptation and mitigation in relation to global context

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ABSTRACT

Climate change has extremely damaged the whole world, particularly South Asian countries because common residents in this region are considered highly vulnerable to climate change impacts whereas their common awareness to adapt and mitigate these impacts is very low. Pakistan is one of the most important South Asian countries and has been affected tremendously through several impacts namely; temperature rise, drought, pest-diseases, health issues, seasonal and lifestyle change and it has the potential to continue doing so in future. We conducted a survey to explore the adaptation and mitigation alertness to climate change among all provinces and areas (urban, peri-urban and rural) of Pakistan from general public since they are directly affected by climate change. In Pakistan, climate change is essentially caused by greenhouse gas (GHG) emissions and the foremost sources of rise in the GHG emissions are human activities, such as deforestation and emissions from various sectors; transportation, industrialization, urbanization, waste, agriculture livestock & forestry and energy usage. All of these have a significant impact on climate change in all areas and provinces. The study determines that all the areas in Pakistan played an increased role in climate change, but rural, peri-urban, and small cities turned out to be in worst situation due to lack of attention and ignorance. Datum produced from this study can pave a way for assisting in preparing, instructing, and guiding national and international decision makers in order to upgrade the levels of adaptation and mitigation policy making and its implementation in South Asia specially and at global scale generally.

1. Introduction

The term 'climate' means basic weather conditions (e.g. pressure of atmosphere, change in wind flows, rainfall patterns, humidity index, variability of temperature, increasing smog etc.) of a specific region and any statistical change in that weather pattern over a certain period of time can be defined as "climate change". Climate change is not an unfamiliar term anymore with significant changes in climate already being visible globally (Kayani et al., 2018), and expected to become more pronounced as we move forward. Climate change has caused extensive concern around the world (Liu et al., 2016) and its coequences are gradually increasing at regional and local scales (IPCC, 2007), which needs instant action as the proactive and precautionary cost will be nominal than the cost of prolong and delayed action (Mudombi et al., 2017). The primary cause of global climate change is greenhouse gas (GHG) emissions that results in warming of the atmosphere (IPCC, 2013) and the

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foremost sources of rise in the GHG emissions are human activities through fossil fuel combustion, industrial production processes (Yousaf et al., 2017a), agriculture and forestry, human society, and vehicle usage (Huang et al., 2016). These GHG emissions consist of carbon dioxide (CO_2) gases (Yousaf et al., 2017b), and also some other non-CO_2 greenhouse gas (such as CH_4, N_2O, HFC, PFCs, and SF_6). In 2010, the emissions rose by an unpredictable 5.8% globally (Carter et al., 2015) and similar rise was seen in Pakistan as well.

A previous study conducted on Pakistan expressed that this change in climate has the potential to seriously harm the country with its massive environmental, economic, and social impacts (Khan et al., 2016). In 2012, the total GHG emissions from various sectors of economy were 367 Tg (teragram) which consisted of 179 Tgns CO_2 emissions, 107 Tg CH_4 emissions, and 81 Tg N_2O emissions (Mir et al., 2017) whereas by 2050, the GHG emissions are predicted to increase up to 4621 Mt (metric tons) (Abas et al., 2017). The three-fourth of total emissions is contributed by CO_2, increased by 42% from 1990 to 2010 (U.S. EPA, 2016). Currently, Pakistan is ranked 135th globally according to per-capita income and is sharing merely a 0.8% of total global GHG budget but by 2030 an increase in this global ranking is expected owing to, increase in transport, waste and energy, and rapid urbanization (Jibran et al., 2015). With a high level of poverty, lack of financial and physical resources, Pakistan is considered a country with low adaptive capacity (Abid et al., 2015) and is already experiencing an increase in the occurrence and intensity of climatic happenings such as droughts, floods in certain regions, extremely fluctuating temperatures, water scarcity, and pest-diseases (Abid et al., 2016). The formulation of a thorough strategy to assess GHG emissions on account of anthropogenic actions and to prepare a comprehensive plan for mitigation or adaptation of GHG emissions is necessary in all the major sectors such as transportation, industrialization, urbanization, waste, agriculture (agriculture, livestock & forestry) and energy usage.

Two international approaches to handle climate change are adaptation, which is human involvements in addressing the effects of climate change and mitigation, initiatives to cope with response of climate change (IPCC, 2001). In order to step up capacity building in Pakistan, it is of extreme importance to improve the understanding of climate change mitigation and adaption initiatives among government decision makers, businesses and individuals, especially incorporating adaption and mitigation into national, provincial, and local level, as well as through area wise (rural, urban, peri-urban) because Region-wise climate change networks provide basis to formulate policy systems for innovative trends by disseminating information about the timing, volumes of climate impacts and recognition of perspective response options (Reckien et al., 2018).

There are limitations in previous literature on Pakistan's climate that shows the impact of concerned sectors (transportation, industrialization, urbanization, waste, agriculture, and energy usage) at provincial and area level. In order to make the public engaged in proactive adaptation against the climate change impacts, the local governments are most successful choice with their prime focus on cities, towns and regions. The local authorities are effective public functionaries that play a pivotal role for adaptation by regulating the use of land, protection of infrastructure, emergency planning and inspection (Vogel and Henstra, 2015). Moreover, to deeply understand the vulnerability at local level and responses to climate change, field-based studies are necessary (Moser and Luers, 2007). As this study is a field-based research, this will provide a significant contribution in understanding and enhancing the knowledge related to climate change and assisting policy makers in developing effective and efficient policies at provincial and regional level particularly in South Asian countries. Common inhabitants in these countries are regarded as highly vulnerable to climate change impacts, whereas the adaptive capacity of these countries is very low due to high level of poverty, increased population density, and scarcity of resources (Ahmed and Suphachalasai, 2014), such as Pakistan. Here we hypothesize that variety of sectors (transportation, industrialization, urbanization, waste, agriculture, and energy usage) will significantly affect the climate and also argue that insufficient attention has been given to the impact of these sectors on climate change at regional level.

To achieve the desired objectives of this study we explicitly examine and compare variety of sectors (transportation, industrialization, urbanization, waste, agriculture, and energy usage) that affect the climate across all the Pakistan. Moreover to enhance the understanding on climate change, the responses and knowledge of people about the pattern of climate change, responsible bodies to cope climate change and importance of this issue at regional and provincial level accordingly were investigated.

2. Methodology

2.1. The study area

In order to achieve the research objectives, we have selected Pakistan as the sample of the study due to severe changes in its climate during the last decade. Pakistan is one of the top ten countries badly affected through climate change. As compared to Pakistan's per capita share of global GHG emissions, the per capita impact of climate change on Pakistan is very high (Abas et al., 2017). The Climate change has tendency to harm Pakistan substantially with its enormous environmental, economic and social impacts (Khan et al., 2016). Pakistan is the 6th most populated country in the world, and ranked 36thlargest country according to area. Pakistan can be classified as a developing country with agriculture being the backbone of Pakistan's economy, which accounts for 19.5% of gross domestic product, employs around 42.3% of the country's labor force, and provides raw material for various value-added industries. Hence, it plays a crucial role in reducing poverty, providing food security, and increasing national development. The literacy rate in Pakistan is around 58%, while the per capita income is 1629 US dollar per annum (Gdp et al., 2017) and the population share below poverty line is 29.5% (Centre, 2017).

Pakistan is located in one of the most significant geographical location around the globe between latitudes 241°–371° North and longitudes 611°–751° east. Pakistan enjoys its strategic location in South Asia with India to the east, China to the northeast, Iran to the west, Afghanistan to the northwest and Arabian Sea and Gulf of Oman in the south. The elevation levels are extreme, with lowest point being in Indian Ocean at 0 m and highest point being on K2 at 8,611 m. The administrative units of Pakistan include four provinces namely Punjab, Sind, KPK (Khyber Pakhtunkhwa), and Baluchistan, a group of FATA (federally administered tribal areas), Gilgit-B & AK (Gilgit Baltistan & Azad Kashmir) and one federal capital territory, Islamabad. The total population of Pakistan is estimated to be 2.08 billion with an annual growth rate of 2.4%, out of which urban population consists of 36.4% and rural population consists of remaining 63.4%. Punjab is the most populated province amongst all provinces, with a population of 110,012,442, an area of 205,344 km^2 and population density of 445.01/km^2. Sindh has a population of 47,886,051, an area of 140,914 km^2 and population density of 392.05/km^2. KPK has a population of 30,523,371, an area of 74,521 km^2 and population density of 360.93/km^2. Baluchistan has a population of 12,344,408, an area of 347,190 km^2 and population density of 37.91/km^2 and the federal capital, Islamabad, has a population of 2,006,572, an area of 906 km^2 and population density of 1271.38/km^2 (Fig. 1).

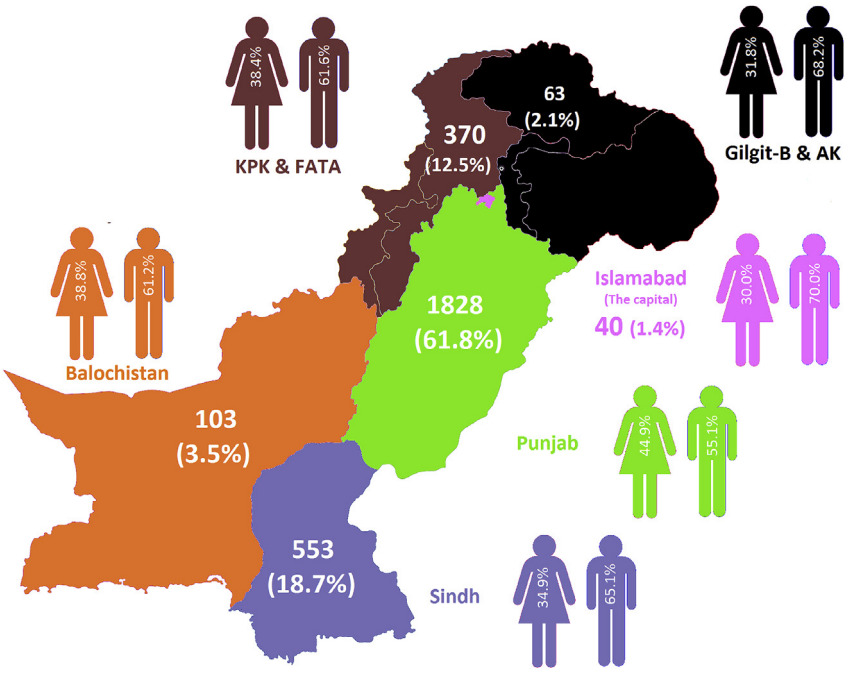

Fig. 1. Classification of sample size from various regions in Pakistan.

2.2. Data collection

For the data collection purposes, both primary and secondary sources were used. The primary data was collected using a questionnaire-based survey and the secondary data was collected through online resources (Web of Science, Science Direct, Google Scholar, USTC's online library) which contained 29 years of climate change data (1988–2017) of the six sectors namely transportation, industrialization, urbanization, waste, energy usage and agriculture. Since the purpose of current study is to understand and analyze the climate change impact faced by common people in the area under consideration. For that reason, this study involved a sample size of general public from all provinces and areas to whom climate change directly affects. According to (Yin, 2003), this case study as an empirical research examined climate change as a contemporary phenomenon within practical perspective, and in which the boundaries between the phenomenon itself and its perspective were not clearly apparent. In agreement to (Benbasat et al., 2002), a study in natural setting can be beneficial for learning and generating insights from practice (Yin, 2003).

The questionnaire was distributed throughout the country in both printed out hard form and soft form. The online questionnaire was formed using Google Forms (https://goo.gl/forms/7fTK2lsZJshOzpKH3) and distributed through social websites such as Facebook, WhatApp, WeChat, and emails. Some farmers and illiterate people were also invited to participate in face-to-face questionnaire-based interviews. During the interview process, we explained every question to the respondent in his/her native language for the purpose of fully understanding the questions. The key motive of filling out questionnaires in hard forms, spreading them out in soft forms, and taking interviews was to gain information and understand viewpoint of maximum amount of respondents related to the reasons and impacts of climate change in Pakistan. The tools utilized for data analysis included Microsoft Excel, SPSS 16, OriginPro 9.0, Sigmaplot 11.0, R and statgraphics 18. The survey was conducted from January till October, 2017. The aim of collecting primary data was to comprehend the ground realities about climate change and compare the obtained results with previously available data (secondary data) which led to an extensive understanding about climate change in our study area.

This study provides a mixed approach which included both, quantitative and qualitative data. The purpose of this mixed approach was to collect maximum amount of data for a deeper understanding of the study area. After data analysis the brief summary of results were sent to the respondents for the clarification of rightly interpreted data. A total number of 3200 (soft 787 + hard 2,413 = 3200) questionnaires were filled from which 243 were excluded from our sample size due to several reasons like incompletion, error in filling, intentionally falsifying filling etc. Therefore, our final sample size became 2957 (3200–243 = 2957) and it took the respondents approximately 30–40 min to finish the questionnaire. The survey questionnaire was formed together with the assistance from professor and post doctorate students following general questionnaire design principles. These principles included questions following a logically relevant pattern, which were consistent and focused on the study area and were not inductive in any way. A pilot study was conducted on January 15th, 2017, to determine whether the questions are covering the kind of information that is required for achieving our research objectives. Around 300 people attended that meeting in which professors, associate professors, assistant professors, post doctorate, Ph.D. scholars and master students were present and expressed their satisfaction towards the questionnaire.

The questionnaire consisted of three main sections which were a summary of all CO_2 emissions instigated by human activities in various sectors (transportation, industrialization, urbanization, waste, agriculture, and energy usage) and a few questions related to climate patterns, effects and importance, whilst it also ensured our commitment to confidentiality. The questionnaire included 62 questions (which included polar questions, likert's 5-point scale, and extensive 10-point rating scale) and was grouped into three separate sections, which were about: (1) climate change and its impacts, the purpose was to gain knowledge about climate change and to recognize multiple impacts caused by it, (2) climate change

adaptation and mitigation, the purpose was to comprehend the reasons of proposed variables and identify the extent of their effects on climate, (3) Demographics, the purpose was to attain basic information of the respondents in order to form relation between their demographics and climate change (for the purpose of privacy, the name and contact information of respondents were proposed as an optional question).

3. Results

3.1. Demographic profile of the sample

The research survey was conducted in all provinces and territories of Pakistan where the collected samples were in accordance to their respective share percent of total population. Since Punjab is the most populated province with 52.95% of the total population, therefore the sample size from it was the most, that is 61.8% and Sindh being the second largest province with population share of 23.04%, the sample size from it was 18.75. Similarly, from KPK& FATA 12.5%, Baluchistan 3.5%, Gilgit-B& AK 2.1% and Islamabad 1.4%. From the collected samples, the share of urban area was 55.01%, share of rural area was 34.46%, and remaining 10.45% was from peri-urban area. The gender distribution accounted for 58.47% of male respondents and remaining 41.53% of female respondents, whereas age ranged from 15 to 75 years, with an average age of ~29 years. Looking at educational background, over 60% of the respondents were graduated from universities, 24% completed their postgraduate, 13% were intermediate,1.2% attained some technical education, and 0.5% completed primary education while 0.6% has received no formal education. Professionally, over 50% of respondents were students, 18% were associated with teaching department, and remaining all were associated with a range of numerous professions i.e., agriculture-related professions 6.6%, office workers 5.1%, researchers 2.9%, entrepreneurs 2.4%, social workers 1.9%, medical professionals 3.7%, and highly skilled professionals 3%. Out of all these professions, a total of 42.6% were associated with government organizations, 38.2% were associated with private organizations and remaining 19.2% were not associated with any sector (Table 1). In order to evaluate the level of significance of different sectors (transportation, industrialization, urbanization, waste, agriculture and energy usage) on climate change of our surveyed sample Chi-square test was performed.

Table 1
Statistical demographic data analysis of field survey from Pakistan.

Variables	n	Chi-square value	level of significance
Area:		18.299	(<0.05)
Urban	1629		
Rural	1019		
Peri-urban	309		
Province:		42.858	(n.s)
Punjab	1828		
Sindh	553		
Khyber Pakhtunkhwa	370		
Baluchistan	103		
GilgitBaltistan	32		
Islamabad	40		
Azad Kashmir	31		
Gender:		11.777	(<0.038)
Male	1729		
Female	1228		
Age:		1.924	(<0.000)
15–25	2109		
26–35	631		
36–45	134		
46–55	28		
56–65	23		
66–75	20		
Above 75	12		
Education:		28.398	(<0.05)
None	18		
Primary	14		
Intermediate	382		
Graduate	1798		
Postgraduate	709		
Technical	36		
Sector:		12.228	(n.s)
Government	1260		
Private	1129		
None	568		
Profession:		48.494	(n.s)
Student	1676		
Teaching	526		
Agriculture	194		
Office worker	151		
Researcher	85		
Businessman	70		
Social worker	57		
Medical professionals	110		
Highly skilled professionals	88		

Level of significance $p < 0.05$.

3.2. Factors contributing most to climate change

In order to fulfill the research objectives, a multi-disciplinary and integrated approach was implemented in the study. For an extensive understanding, the selected variables were: transportation, industrialization, urbanization, waste, agriculture, and energy usage. According to the findings of our survey in whole Pakistan (Fig. 2), the most important concern to climate change was transportation, marginally higher than industrialization, followed by urbanization, with nominal difference by waste, subsequently agriculture, and energy usage. The findings of provinces revealed a similar picture. In Punjab region, the results were identical to that of whole Pakistan's, with only waste share being higher than urbanization and remaining variables followed similar pattern. In Sindh, Gilgit-B & AK regions, the results were again identical to whole Pakistan, with the exception of agriculture's share being slightly higher than that of waste. In KPK & FATA regions, the findings turned out exactly identical to whole Pakistan, following the same share rating. In Islamabad & Baluchistan regions, the findings showed that industrialization caused a higher concern than transportation, remaining variables indicated similar pattern to the ones revealed in whole Pakistan.

To classify the findings into areas (urban, rural & peri-urban), the results of whole Pakistan revealed that in urban areas transportation has a higher impact on climate change, with industrialization causing similar impact, trailed by urbanization, waste, agriculture, livestock & forestry, and energy usage (Fig. 3). In rural areas, the findings were almost indistinguishable from urban areas where impact of waste was marginally higher than urbanization, remaining variables were identical. In peri-urban areas, the share value of industrialization peaked followed by slight difference of transportation, waste share also increased which was followed by urbanization, agriculture, and energy usage. The findings of Punjab region portrayed a similar picture to whole Pakistan's. In urban areas, the impact of waste slightly rose above urbanization whilst remaining factors remained similar to whole Pakistan's findings. In rural areas, the results looked similar to urban areas of Punjab, with waste having higher impact than urbanization. In peri-urban areas, the share rating was identical to whole Pakistan. The findings of Sindh were not farfetched from whole Pakistan.

In urban areas, transportation, industrialization and urbanization displayed similar impact of climate change, followed by agriculture, waste and energy usage. In rural areas, agriculture share dropped, followed by waste and energy usage, remaining factors

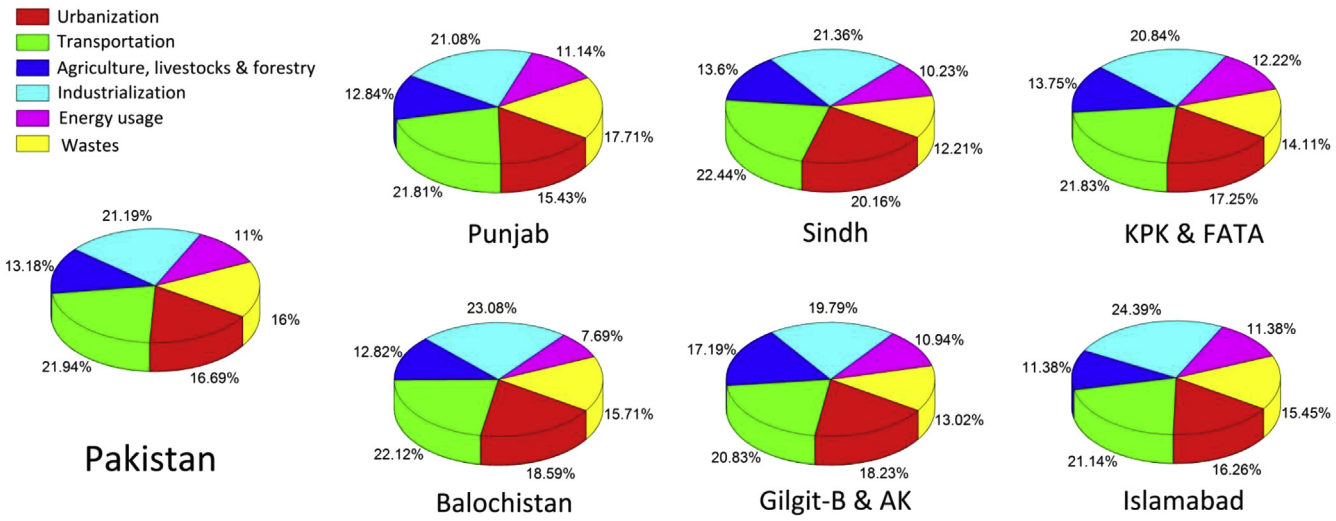

Fig. 2. Sectoral segmentation across the provinces of Pakistan.

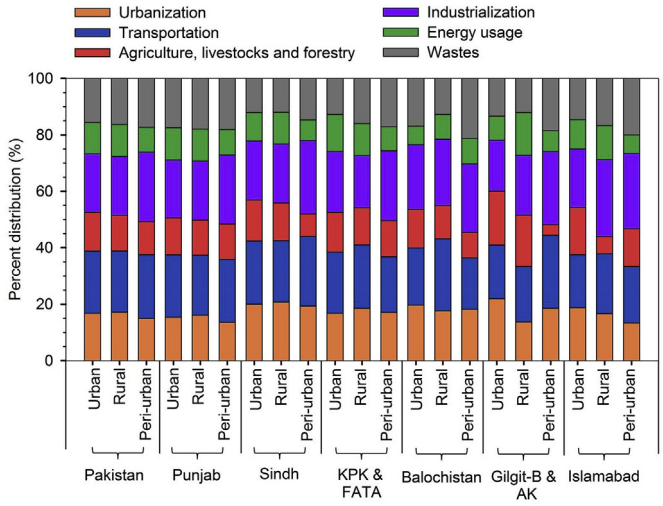

Fig. 3. Sectoral segmentation across the areas of Pakistan.

showed identical impact with urban areas. In peri-urban areas, transportation and industrialization had an increased impact followed by urbanization, waste, agriculture, and energy usage. The findings of KPK and FATA regions followed similar pattern to that of whole Pakistan's. In urban areas, highest share was of transportation and industrialization, whilst urbanization, agriculture, energy usage and waste remained low. In rural areas, the impact of transportation and urbanization was slightly higher followed by industrialization, waste, agriculture and energy usage. In peri-urban areas, industrialization had the highest impact, with transportation, urbanization and waste having similar impacts which was followed by agriculture and energy usage. The findings of Baluchistan region were very close to whole Pakistan. In urban areas, industrialization had the maximum impact followed by urbanization and transportation having similar impact, subsequently waste, agriculture and energy usage.

In rural areas, share of transportation and industrialization increased, remaining factors followed a similar pattern as in urban areas. In peri-urban areas, industrialization had a higher impact, with waste also contributing highly, followed by urbanization, transportation, agriculture, and energy usage. The findings of Gilgit-B & AK showed similar outcomes to that of whole Pakistan's. In urban areas, there was increased impact of urbanization, while transportation, industrialization, agriculture remained similar, followed by waste and energy usage. In rural areas, transportation and industrialization had a higher impact on climate change with slight difference to agriculture, whereas urbanization, energy usage, and waste had less impact. In peri-urban areas, the share of transportation and industrialization went up, while urbanization and waste also shared strong impact, followed by energy usage and agriculture. The findings of Islamabad region indicated parallel results with whole Pakistan's. In urban areas, the most impact was caused by industrialization, whilst transportation and urbanization causing similar impacts, followed by agriculture, waste, and energy usage. In rural areas, the results were equivalent to rural areas with the exception of increased waste and energy usage share. In peri-urban areas, industrialization had the highest impact but waste and transportation contributed highly as well, followed by similar impact of agriculture and urbanization, whilst energy's impact kept low. After statistical analysis, the results of step-wise forward regression turned out to be almost identical with our quantitative discussion and model was statistically satisfying with merely an exception of agriculture turning out to be non-significant (Table 2). Climate change was taken as dependent variable which was comprised of general diverse influence of independent variables. On the other hand different sectors namely; transportation, urbanization, industrialization, waste, energy use, and agriculture were considered as independent variables.

The R-Squared value was calculated to be 12% and the possible reasons for observance of lower score R-squared value could be that

Table 2
Statistical description of testing significance using Step-wise Forward Regression analysis.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Industrialization	.142***	.213***	.171***	.198***	.164***	.161***
Urbanization		.141***	.189***	.079*	.148**	.155**
Energy usage			.141***	.160***	.094*	.091**
Waste				.187***	.132**	.132**
Transportation					.253***	.248***
Agriculture						.220ns
F-value	18.835*	16.577*	15.654	15.906	24.186	20.188
R^2	.020	.035	.049	.065	.118	.120

Dependent variable: Climate change.

the constructs are overlapping each other's effects while collectively defining the psychological behavior of individuals towards 'Climate Change' as a phenomenon. Another reason could be that the prominent relatedness of each of the independent construct can be less obvious into the society. As none of the previous studies ever considered these all constructs together. In current circumstance, it can be concluded that R-squared value of 12% has reasonable impact on climate change (Jacob Cohen, 1988). The 'low' and 'high' values of R-square are dependent on the specific variables and population under investigations (Kruger and Dunning, 1999). There is no issue of multicollinearity between variables, as the value of variance inflation factor ranges from 1.3 to 2.5 (Table S1). Although our variables have no issue of multicolinearity, but the purpose of applying ridge approach was to minimize the variance from true value that provides more reliable results where ridge parameter was calculated as 0.106747 (Fig. S1) (Table S2).

The demographics findings of the gender (male and female) indicated that the most important concern to climate change according to male population of the sample was transportation, fractionally more than industrialization, followed by urbanization, with nominal difference to waste, subsequently agriculture and energy usage. The findings of female population of the sample revealed identical results to that of males (Fig. 4). According to the findings of educational background, results of the uneducated sample revealed that the most important concern to climate change was transportation followed by similar impact of agriculture and urbanization, subsequently industrialization, waste, and energy usage. The sample with primary education indicated similar pattern as of uneducated sample with an exception of industrialization being a higher concern than agriculture. The sample with intermediate education identified that industrialization was a higher concern than urbanization and agriculture whereas waste was presented as higher concern as well. The sample with graduate education displayed identical results as of uneducated sample except waste was regarded as a higher concern than urbanization. The sample with postgraduate education revealed that industrialization was a greater concern than urbanization and agriculture whilst waste was also a higher concern. The sample with technical training displayed parallel results with uneducated sample with the exception of waste being a higher concern than agriculture and urbanization (Fig. 5).

To classify the findings into age, all of the age group results revealed that the most important concern to climate change was urbanization with an impact range of 64%–79%, followed by transportation with a range of 15%–27%, subsequently agriculture with an impact range of 3%–7%, while remaining all were below 2% (Fig. 6). The results of OR (Odd Ratio) test demonstrates that professionals working in various fields were most aware of climate change compared to students (OR = 1.119). Similarly, people with higher education were more aware of climate change than people with lower education (OR = 1.106), people working in private sector were more aware of climate change than that of government employees (OR = 1.074), and female participants were slightly more aware of climate change than males (OR = 1.040). On the other hand, urban area residents were more aware of climate change than residents from rural areas (OR = 0.924) and people below 25 were more aware of climate change than people above 25 years (OR = 0.860) (Table S3).

3.3. Awareness about climate change

According to Fig. 7, the findings of change in weather pattern over the years elaborated that in whole Pakistan over 75% of the respondents believed that pattern of weather has been changing year by year whilst remaining 25% believed that it is not the case. In order to comprehend a deeper understanding, we divided the results of whole Pakistan into provinces. Out of the 75% agreed responses, Punjab ranks the highest with a 62% share, trailed by Sindh with 17% share, subsequently KPK & FATA, Baluchistan, Gilgit-B & AK and Islamabad. Out of the 25% disagreed responses, Punjab again ranks highest with a 60% share, followed by Sindh with 23%, afterwards KPK & FATA, Baluchistan, Gilgit-B & AK and Islamabad. The results can be seen completely aligned with the country's population metrics and the sample size identified in the study. Similarly, as an alternative approach for perceptive understanding results of whole Pakistan were distributed into areas. Out of the 75% agreed responses, sample from urban areas contributed 52% of share, followed by rural areas with 37% share, and peri-urban with a mere 11%. The remaining 25% of disagreed responses from the sample followed almost identical pattern to agreed responses.

3.4. Importance of climate change

The findings of importance of climate change personally revealed that in whole Pakistan, over 62% of the sample believed climate change is a very important issue, 25% expressed that it is quite important, 8% disagrees that it is not an important issue, whereas 5% of the sample are not sure about climate change. The results can be seen completely aligned with the country's population metrics and the sample size identified in the study. Similarly, an alternative approach for perceptive understanding can be distributing the results of whole Pakistan into areas. In urban areas, the results were nearly identical to Pakistan's, with the exception of very important share being slightly lower and quite important slightly higher. The findings of rural area and peri-urban, followed almost similar pattern of whole Pakistan. The findings of all provinces matched the findings of whole Pakistan with a similar pattern, with an exception of share of not being sure higher than

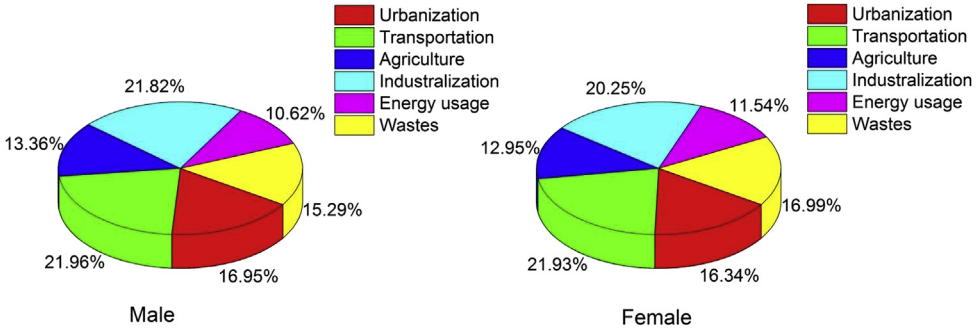

Fig. 4. Sectoral segmentation across the genders of Pakistan.

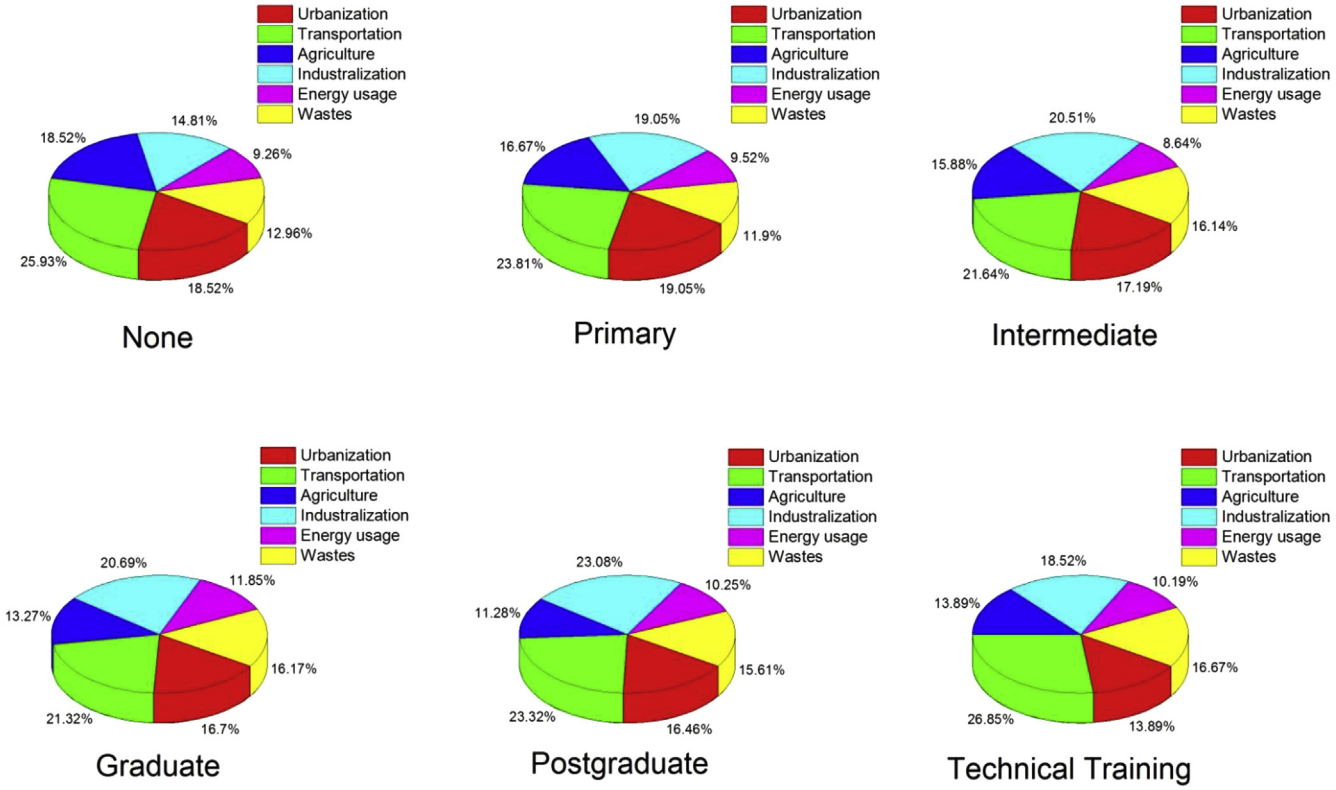

Fig. 5. Sectoral segmentation across the education level of Pakistan.

not being an important concern in Punjab and Sindh provinces. The results of this approach were also consistent with the sample size of the study (Fig. 8).

3.5. Climate change adaptation and mitigation measures

The findings of responsible bodies for tackling climate change revealed that in all areas (urban, rural and peri-urban) over 41% sample delegated the responsibility of tackling climate to all organizations (international organizations, environmental organizations, businesses and industry, city residents, village residents, the national government, local government, and individuals), whereas 21%–23% claimed that it is international organization's responsibility, subsequently 12%–15% claimed it to be environmental organization's responsibility, and below 7% claimed it as responsibility of the rest of the organizations. The findings of provinces exhibited almost similar pattern with that of the areas (Fig. 9). The purpose of this question in the study was to estimate a general level of knowledge among the sample with accordance to climate change.

3.6. Impact of climate change in Pakistan

According to Fig. 10, the findings of climate change impacts (increase in temperature, drought, pest diseases, human health issues, seasonal change, and lifestyle change) in main residential area in whole Pakistan indicates that over 54% of the respondents believed that there is a significant rise in temperature, whilst 32% believed that there is a moderate rise in temperature, 10% believed that the change is quite low, and 4% did not observe any change. In the case of droughts, moderate change was seen by48%, whereas low change and significant change ranged from 21% to 24%, followed by 7% of no apparent change. In case of pest diseases, moderate change was observed up to 42%, however 37% of significant change, followed by low and no change. The findings of health issues revealed almost similar results to rise in temperature whereas findings of seasonal change were closely identical to rise in temperature with the exceptions of decrease in the share of significant change and steep increase in the share of no change. The findings of lifestyle change results were almost identical to pest diseases with only exception of slightly decrease in moderate change.

Additionally, the findings of all areas of Pakistan were almost undistinguishable with whole Pakistan with some exceptions of health issues being lower in all areas than in whole Pakistan, rise in temperature in peri-urban area had a significant change than whole Pakistan, and lastly, moderate change in seasonal change was marginally lower than whole Pakistan. Similarly, the findings of all provinces of Pakistan were nearly identical to whole Pakistan with the exception of significant change in rise in temperature was higher, no change was lower, share of droughts was lower, and low change in seasonal change was lower in Baluchistan. In Gilgit-B & AK, low change in rise in temperate was lower, no change in pest disease was higher and significant change in seasonal change was higher. In Islamabad, moderate change in rise in temperature was lower, significant change was higher, whereas moderate change in droughts was higher, significant change was lower, same was the case with pest diseases.

4. Discussions

According to the findings of our survey, we determined that the most important threat to climate change in Pakistan is transportation, afterwards industrialization and urbanization with marginal differences, and then waste, agriculture, and energy usage. The results revealed that above mentioned sectors were very

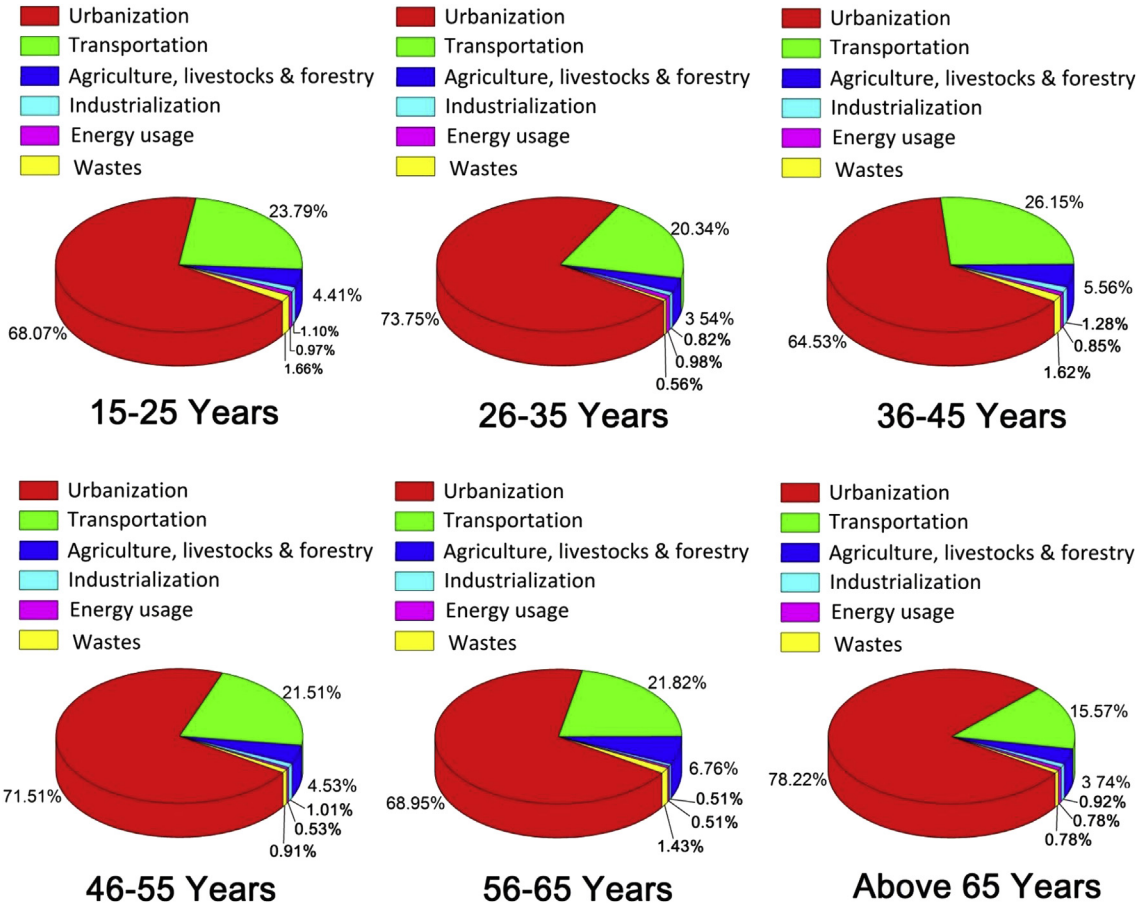

Fig. 6. Sectoral segmentation across the different age range of Pakistan.

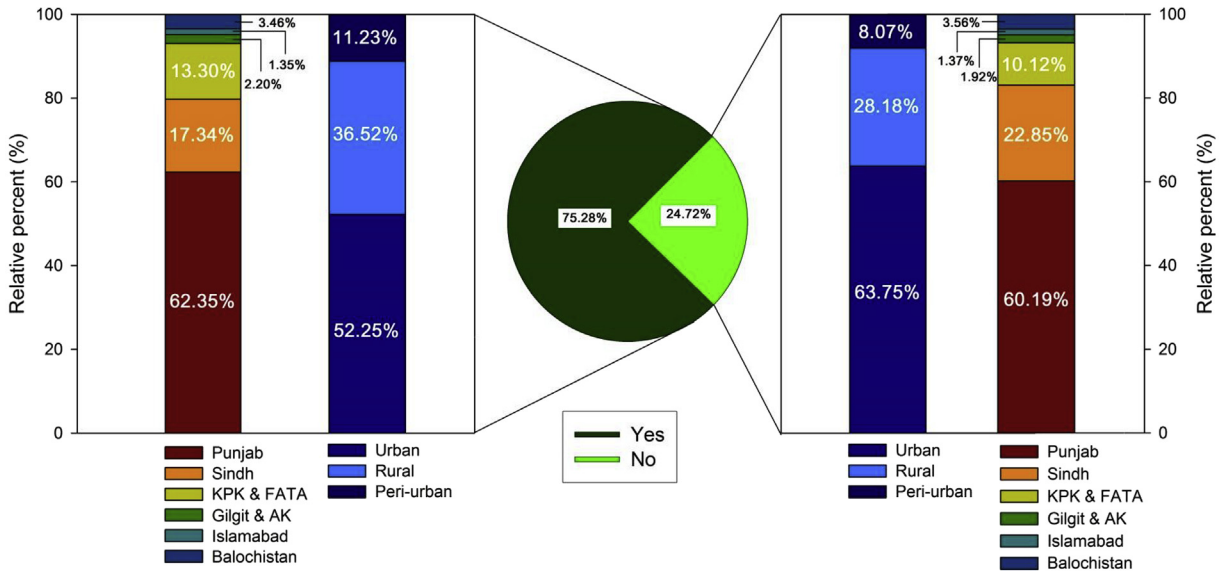

Fig. 7. Percentage of awareness for climate change across the Pakistan.

important and had high influence on climate change, from which transportation, industrialization and urbanization had much higher share as compared to waste, agriculture and energy usage, all three of which also had moderate impact on climate change. All of the sectors mentioned above contribute greatly towards affecting climate change and indicated a significant impact on climate change in all areas of Pakistan (Tables S4 and S5), Likewise to Pakistan, these sectors also effecting the climate change at global level (Table 3). After statistical analysis, the results of Step-wise Forward regression analysis turned out to be almost identical

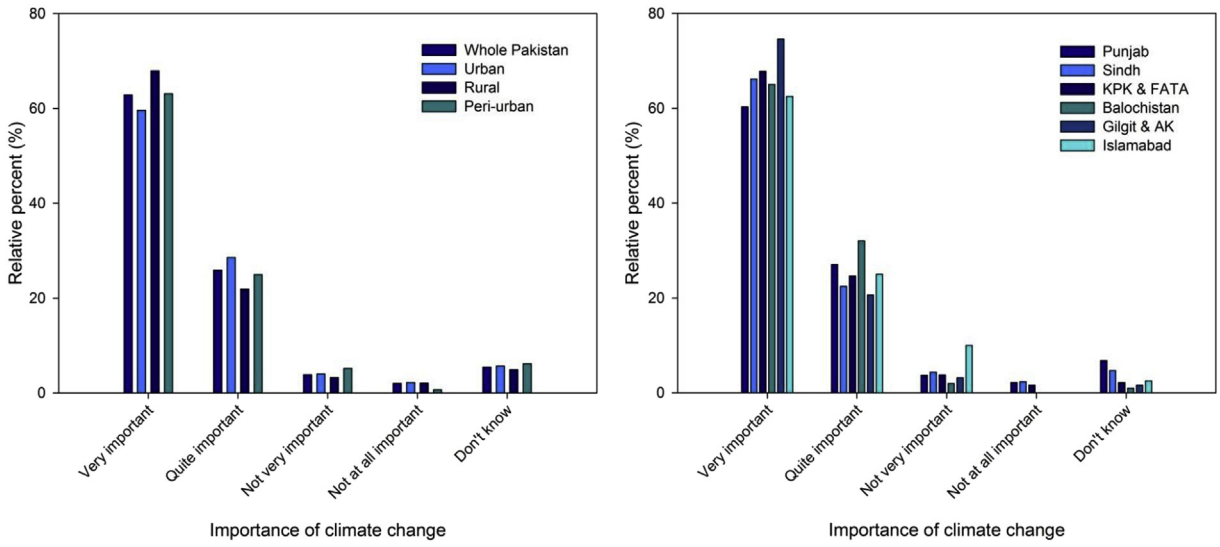

Fig. 8. Relative percentage for importance of climate change across the Pakistan.

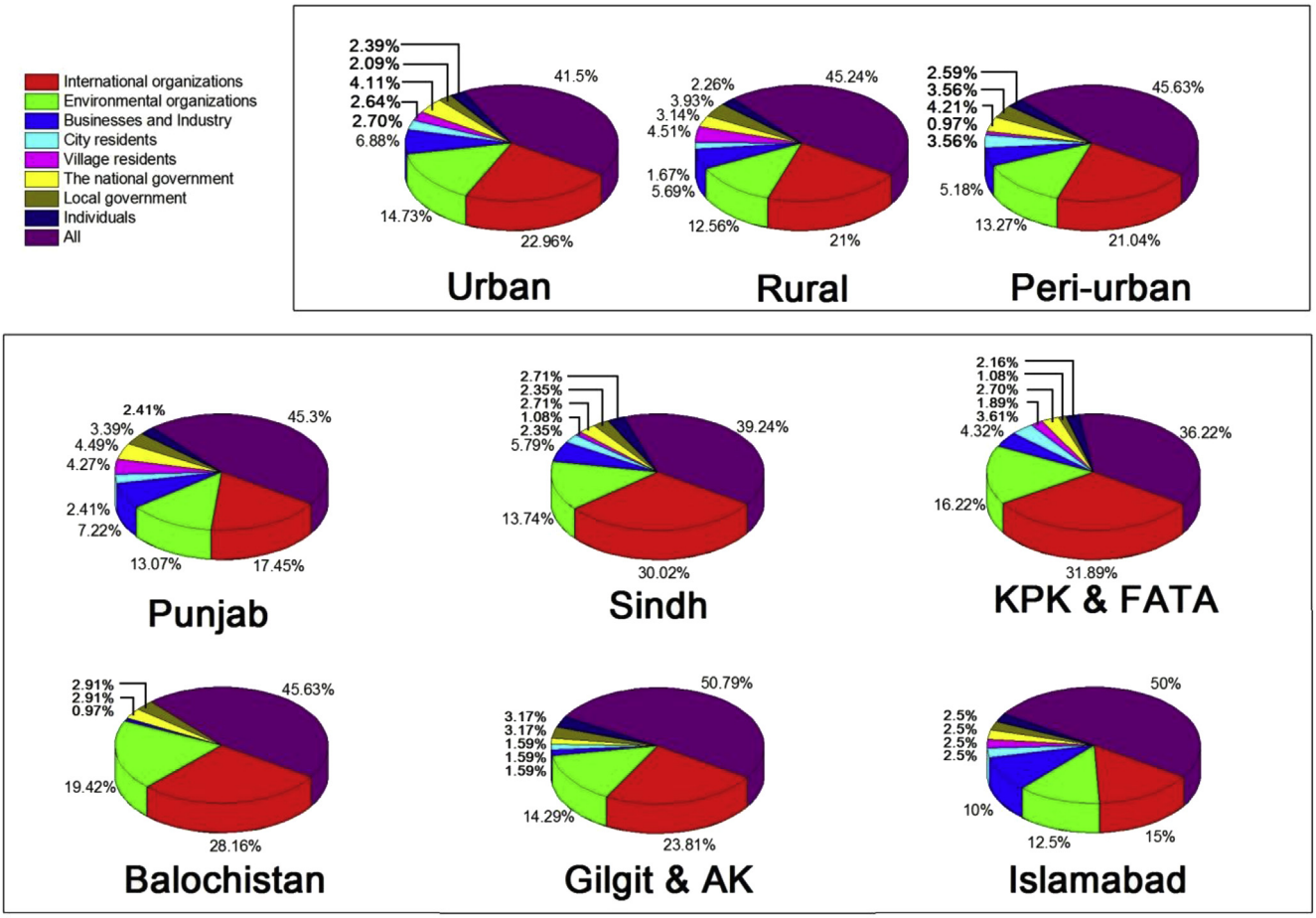

Fig. 9. Percentage of climate change measures by different bodies across the Pakistan.

with our quantitative discussion with the exception of agriculture turning out to be non-significant (Table 2).

Previously conducted studies also revealed that, CO_2 emissions from transport, industry practices, baring forests, biomass and waste from crop-burning, and combustion of fossil fuel (Cochran and Brunsell, 2012) have caused endangerment to the atmosphere at a higher extent which aligns perfectly with our study's findings, which showed that the transportation sector is the highest contributor of climate change in Pakistan, in all provinces, areas and even demographic profile of our sample. Emissions from

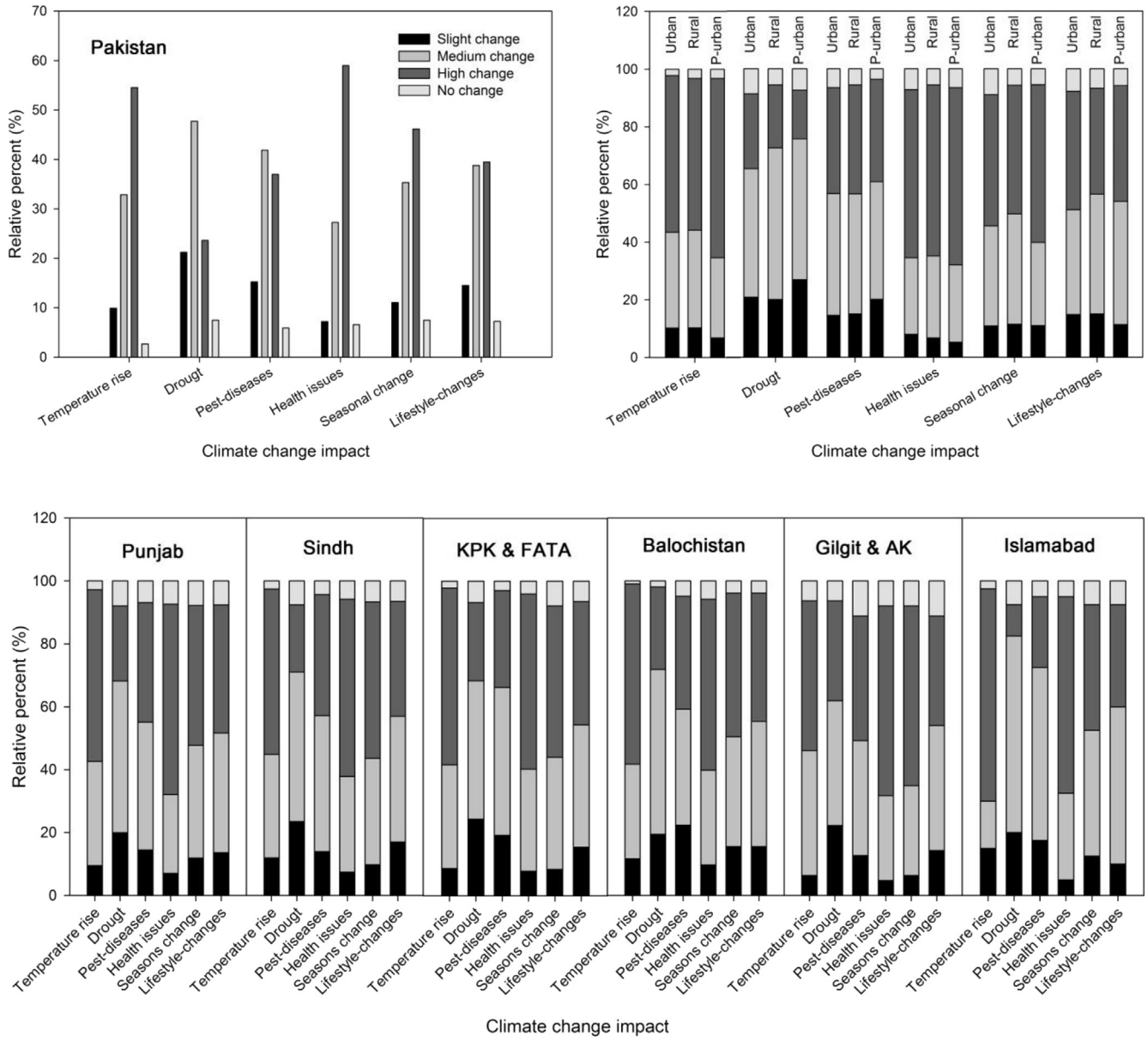

Fig. 10. Relative percentage of climate change impact on whole country.

transport is responsible for significant share of total national CO_2emissions and transport sector has shown the highest emissions among all sectors and accounts for about a quarter of carbon dioxide emissions in Pakistan (Of and Change, 2012) and is considered to be one of the highest GHG emitting sector where emissions are still increasing (Lin and Ahmad, 2016). Road transport is considered to be the most renowned form of passenger transport in Pakistan where over 90% of the passenger traffic and about 96% of cargo & shipping is conducted (Ul-Haq et al., 2017). The main public transportation in the country included railway, buses and wagons where the condition of railway has also been much problematic with the performance and condition of railway diminishing as the internal traffic share decreased from 41% to 10% for passengers and 73%–4% for freight traffic, since the traffic conditions in Pakistan are far behind western and developed countries and unimplemented national transport policies for betterment of urban and rural transport, the issues that need addressing includes environmental degradation, shortage of quality public transport, urban traffic congestion, and other negative spillovers from transport sector especially road safety (Askari, 2009). Lack of quality and reliable public transportation is causing a significant rise in harmful emissions since the residents prefer private means of transport and residents of rural areas scarcely use public transport on account of all above mentioned issues, as well as proximity and lack of schedule. According to Table S6, the main reason behind lesser usage of public transportation is lack of quality and reliable transport and climate awareness that leads to the usage of private or personal transportation mediums whereas unreasonable and unethical behavior by the public transport owners, staff and on-board crew were another few reasons. Specifically, in rural areas, ignorance of transport rules and regulations, large distances between stations and the stopping points being farther apart from each other compel residents to avoid public transport and utilize private means of transport. Unexpected increase in private and public transportation accelerating the emissions of greenhouse gases (GHGs) and is likely to escalate at a faster pace

Table 3
Contemporary studies of climate change impacts by various sectors and adaptation & mitigation measures.

Country	Adaptation/ Mitigation	Initiative	Description	Reference
Tanzania	Adaptation	The studies show the role of local environment bodies in implementing the climate adaptive measures in Tanzania.	The study reveals that the prime policy focus builds an anti-politics, terming the adaptation against the climate changes as constant and generalized threat to their conventional farming. This is due to complicated government structure and social equity aspects of adaptation toward the climate change. A highly depoliticized hierarchy and technocratic vision are required to adapt the climate change impacts. International academic, development and policy circles are also stressing such type of approach for adaptation.	(Smucker et al., 2015)
Sweden	Adaptation	The study highlights the issue to be non- conventional business by conducting a study about the forestry sector in Sweden, a major contributor in the economy and likely to be pre emptive adapter in case of plantation of new forests that can last up to 90 years in future.	The study narrates that adaptation must be taken as controlled and limited by prevailing institutional and Social system phenomenon, rather than by externally defined "rational" drives. Efforts for climate change adaptation must be based on existing bodies' motives, social and environmental motives. In other words, social motives may define the kinds of measures that may be considered as adaptation measures.	(Andersson and Keskitalo, 2018)
England	Adaptation	The recent attention being paid toward this subject matter a question that arises is: whether adaptation of climate change be taken as policy field or not? As the social sciences contain the units of analysis while the definition of policy fields such as environmental policy or agricultural policy is taken for granted.	It reflects that policy fields are three-faceted domains consisted of substantive authority, substantive expertise and institutional order. The secondary task of this study is a practical application of this definition for adaptation policy activities in England and to determine whether the adaptation measures might be taken as policy field or not.	(Massey and Huitema, 2013)
USA	Adaptation/ Mitigation	The proposed framework suggests three important facets of adaptation and mitigations measures which are: preparedness −knowledge of climate-related devastations, evaluative capability to gauge such climate devastative information into precise management, planning magnitude of activities.	The findings of analysis suggests that there is dire need to realize California its considerable adaptive ability and should made itself capable to contain the inseparable adversaries of climate change. Effective engagement of resource managers is required in discussing the future scenario of the climate change.	(Moser and Luers, 2007)
Malaysia	Adaptation	Discussed the adaptation constraints and impacts of socioeconomic factors on climate change adaptation measures in the agriculture sector of Malaysia.	The findings showed that age, educational level, income of farm, agrarian expertise, less frequent access to agricultural extensions, shortage of credit availability, constraints to access to agricultural markets, and size of farm are underlying factors which have considerable impacts on adaptation measures.	(Masud et al., 2017)
France	Adaptation	Discussed that the transportation networks are integral for economic and social development: their adaptation against the climate change has significant importance.	Working groups on transportation having experts of different transport infrastructure came into being in 2011 and are unanimous to boost cooperation to address this problem. They suggested: *i)* a comprehensive review of technical and regulatory parameters that require a modification to adapt construction, maintenance and running of transportation infrastructures and networks to continuous changing climate trends and *ii)* a framework for risk assessment to mitigate the effects of extreme weather on transportation in future. This task of adaptation will be accomplished by a draft aiming at assessing how the climate change would affect the transportation sector and commuters mobility.	(Colin et al., 2016)
Ghana	Adaptation	Adaptation in rural farming due to visible changes in climate.	Findings shows that the changing climate patterns, in the form of erratic downpour and soaring temperatures, have affected the communities engaged in rural farming who have already facing the wrath with limited mechanization of farming.	(Cobbinah and Anane, 2016)
Mexico	Adaptation	Studies show the migration from Mexico as a result of climate change and have mainly focused on rural areas and less focus on urban areas. As a result of less focus the urbanization it turned into a monster.	Findings from multi-dimensional events and history models show that temperature soaring and increased precipitation considerably has increased international migration during this study period. However, only the rural areas have been considered for international migration. Studies show that a casual pathway in which mercury (but not precipitation) affects the patterns of international migration by providing employment in the agriculture sector. Such type of migrations may be declined due to expanding urbanization.	(Nawrotzki et al., 2015)
Australia	Mitigation	This study analyses the efficiency and effectiveness of green and cool roofs as potential Urban Heat Island (UHI) as mitigation strategies, and the effects of these strategies on thermal comfort.	This exercise shows that this is not a description of extreme heat wave caused by dry and warm situations. This study also reveals that initial moisture in soil for green roofs does not have a significant impact on the UHI. Ultimately, green roofs improve human thermal comfort by reducing the Universal Thermal Comfort	(Imran et al., 2018)

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Table 3 (*continued*)

Country	Adaptation/ Mitigation	Initiative	Description	Reference
			Index by up to 1.5 _C and 5.7 _C for pedestrian and roof surface levels respectively, and by 2.4 _C and 8 _C for cool roofs for the same levels.	
UK	Adaptation/ Mitigation	The winter of 2013/2014 witnessed a series of storms hit the UK, causing massive flooding, a large scale emergency response and drew heavy media coverage.	Studies show that direct experience of massive flooding leads to an overall increased salience of change in climate, pronounced psychological responses and more perceived personal risk and vulnerability and risk. We also produce the first fact that direct flooding experience can give hike to psychological intentions beyond individual sustainability measures, including support for mitigation policies, and personal climate adaptation.	(Demski et al., 2017)
Scotland	Mitigation	This study helped to develop a methodology to assist in choosing land-based measures to mitigate GHG emissions region wise. The major criterion applied was the “full” mitigation capacity of each measure.	A variety of methods were applied to conduct this study, namely a review of literature and quantitative strategies. The woodland plantation with Sitka spruce the most effective mitigation measure that produced greatest “full” mitigation output (z66% reduction by 2020 as compared to 2006). Numerous constraints, such as economic, social, demographical, political and institutional, influence the uptake of mitigation steps in a region. As a result the acquired mitigation potential of a measure may be below capacity than its “full” mitigation potential. Focused groups and surveys are required to undertake the concerned stakeholders to assess the region where mitigation practices are being observed to cope the constraints for implementation.	(Feliciano et al., 2013)
China	Adaptation	Study was conducted to find the relationship between industrial structure and wastage emissions in rapidly developing and manufacturing-dominated Chinese cities.	The study recommends that upgraded and improved industrial structure to reduce the polluting emissions can be implemented in only strict legal environment.	(Wang et al., 2018)
USA	Adaptation	Identification of problems and devising of promising solutions is viable approach to address the impacts of local climate change.	The findings show multiple data sources based plans are to evaluate the future impacts of climate change and based on multi-pronged strategies. Most of the plans seem unable to prioritize effects and strategies raising few concerns about the practicalities and vulnerability reductions. Our analysis also reveals that plans devised by the planning department were of more effective quality wise. The findings provide necessary insights for enforcers, policymakers and scientists striving to refine climate adaptation planning and measure region-wise.	(Woodruff and Stults, 2016)
China	Mitigation	Discussed about the rapid increase in urban transportation systems in the form of greenhouse gas (GHG) emissions over the years.	We drew the conclusion that rate of motorization and structure of transport were the underlying factors establishing urban passenger transport associated GHG emissions. Recognizing the great impact of urban passenger transport growth in China, there is acute need of policies guiding the expansion of transport structure specially in eastern provinces.	(Hao et al., 2014)
Pakistan	Mitigation	In the study, a sincere effort has been done to develop inventory of greenhouse gas (GHG) emissions in Pakistan at the national as well as sectoral level.	89% of the total national GHG emissions are being generated by the energy and agriculture. Sectors collectively while the remaining 11% is caused by industrial operations, land use, forestry and waste. A comparative study of GHG emissions shows that GHG emissions have been increased at the rate of 4.1% since 1994 to 2012 and are expected to increase sharply to meet the national development goals. While the per capita emissions will remain low when these are compared to the world average.	(Mir et al., 2017)
Korea	Adaptation	A case study was conducted to operate the emissions disaster facility in Korea's city Seoul and a demonstration was conducted to check the model's functionality.	This study enabled the decision makers to evaluate the economic viability and feasibility for adaptation in the urban areas of the country. To check the effectiveness and volatility of the model technical and economical factors were also taken into consideration to adapt the potential climate change impacts in the urban areas. The model have flexible managerial feature to long run planning and management for infrastructure in urban areas.	(Kim et al., 2017)
USA	Mitigation	This study is in two-parts and evaluates the impacts of estimated GHG emissions from the transportation sector of United States on quality of air in connection with changes in climate.	The critical analysis of the baseline 2005 WRF simulation shows that annual bases are near to or within the set criteria for meteorological output and there is an overall good agreement in the 2005 CMAQ simulations of chemical variables against both surface and satellite observations.	(Campbell et al., 2018)

Table 3 (*continued*)

Country	Adaptation/ Mitigation	Initiative	Description	Reference
Spain	Mitigation	This research article presents a prospective analysis and evaluation of the energy security of a energy system.	The findings show that, despite the comparatively high renewable share sent in a business-as-usual scenario, a considerably higher and faster renewable penetration is obtained while implementing RESI mark of 70%, 80% and 90% by 2030 in Spain. This is found to have direct connection with a large number of installations (onshore and offshore) wind power production technology. At the end a suitable life-cycle climate change performance is achieved while fulfilling energy security missions.	(García-Gusano and Iribarren, 2018)
Australia	Mitigation	This mitigation study critically analyzed the impact of Australia's energy sector on degradation of environment and also critically analyzed CO_2 emissions using domestically collected data on energy generation, energy imports and exports from 1974 to 2013.	As per the sensitivity analysis of the nonrenewable energy generation above 10% and energy imports above 5% will deteriorate the goals of emissions reduction up to 2030. By increasing the volume of renewable energy in the energy sector caused to reduce the level of CO_2 emissions. On the other hand due to the inclusion of non -renewable energy sources in the energy sector caused a considerable increase in the emissions and causing the climate change impacts. Target of emission reduction can be fulfilled by increasing the use of fossil fuels.	(Sarkodie and Strezov, 2018)
Turkey	Mitigation	The study suggests to achieve the sustainable industrial development in Turkey, assessment of carbon based emissions and its environmental impacts is necessary.	One of the main points noted from this study is the unavailability of published country specific emission factors, which is a foundation to promote corporate carbon footprint assessment and evaluation in the Turkey.	(Kılıç et al., 2018)
Cyprus	Adaptation	The study compares the environmental performances with the sustainability of various management options for waste of livestock in Cyprus	The results and evaluations show anaerobic lagoons proved no to be suitable option for the management of waste of livestock. It is not suitable due to environmental (acidification and eutrophication) and impacts of social nature (exposure, visual impact, noise and hazard for human health).	(Lijó et al., 2018)
India	Mitigation	This paper reflects the comparisons of energy emissions and estimates of energy consumption in transportation sector in India up to 2050.	Research finds a considerable differences in the data of base-year and parameter for future predictions, namely energy usage by the transportation sector and service demand for passenger as well as freight transport. The study has highlighted various important data loops as per our information about the Indian transportation sector.	(Paladugula et al., 2018)
Finland	Mitigation	The purpose of this study is to evaluate, how the mitigation policies about climate change and such events have influenced the consumption of household carbon footprints in the Capital Helsinki Metropolitan Area HMA from 2006 to 2012.	The findings of the research study reveal that the average carbon footprint consumption declined to 7% from 2006 to 2012, while the 1% increase in expenses, which is satisfying. Housing energy based usage and motor fuel based consumption declined significantly. In the urban areas transportation and car areas the two outermost areas located in HMA, had the most emission declines. Relatively energy efficient buildings and cleaner electricity had also major effect.	(Ottelin et al., 2018)
Brazil	Mitigation	This study designed and applied a technique to develop an optimum carbon chain considering a substitute concept: the introduction of new CO_2 emission input aiming at securing adequate operational flows, reducing waste and minimizing the transportation costs.	Results show that the introduction of new CO_2 emission inputs minimizes the transportation costs. By including CO_2 from both the process of cogeneration and fossil fuels result in an average transportation cost of 26 US$/t CO_2 (54% lower than costs of transportation in the baseline case). On the other hand, the decline in transportation costs are not the substitute for capture costs.	(Tagomori et al., 2018)
China	Mitigation	The study analyzes how the carbon mitigation loads to be divided among the main carbon emitting sectors of Chinese economy.	This research study reveals that generally, distributing the mitigation burdens on the bases of historical emissions can realize cost efficiency as a national target. However, coal, electricity and transportation sectors can be adjusted. In a short span of time the mitigation target for coal sector should not set too high. In case of deregulated electricity price the burden shared by the electricity sector should be high. To ease the burden the energy sector should be efficient and should have improved energy structure.	(Yao et al., 2018)
Vietnam	Mitigation	This research article overviews the facts and future prospects of production of Biofuel in Vietnam.	Effective and multi-faceted policies from government are the need of hour to boost the bio fuel productions. This sector also requires strict regulation and institutional framework to achieve the desired targets.	(Trinh and Linh Le, 2018)
UAE	Mitigation	This research paper describes the underlying factors ought to be investigated as a result of increase in air traffic in UAE and ultimately eye catching increase in CO_2 emissions in the Abu Dhabi International Airport as	Multiple issues are arising while countering emissions problem. Such issues are: types of fossil fuels, measurement of aviation emissions, and unreliability of	(Bernabeo and Emilia, 2013)

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Table 3 (*continued*)

Country	Adaptation/ Mitigation	Initiative	Description	Reference
		well as in UAE. This study deals with the viable solutions to curb these emissions.	collected data and counting of thousands of flights arriving and departing from the UAE.	
China	Mitigation	Can China slow down the GHG emissions and ultimately reduce the emissions is the main question for climate change mitigation. The emissions include electricity (renewable, nuclear, and coal), transportation, Four industries with sub-sectors (steel, cement, fertilizers, and oil refining).	Research identifies two types of attributes i.e. organizational/political attribute and second is techno-economic attribute. Both of them open the door for climate mitigation. The main influencing factors are the government or market that makes the collective action hard. Sub sectors of the economy cement, steel, and oil refining have both organizational and techno-economic feasibilities. On the other hand fertilizers and renewable energy sources present the challenges on both attributes. Buildings and road transport are up to some extent mixed cases, where organizational/political factors are comparatively tougher than techno-economic factors. Finally, coal and nuclear and coal are the opposite case of the road transport and buildings.	(Busby et al., 2018)
Brazil & USA	Mitigation	The research paper emphasizes on a particular case: biogas produced from organic wastage, a renewable energy source can have impacts on water quality if the same infiltrates the water table.	The research findings reveal that biogas production has plentiful advantages for the whole chain of production including local communities, farmers and the input providers. The research study assessed that bio methane can become the alternative of Brazil's entire gasoline and diesel imports and can take the place of 44% of its diesel usage. 16% of the diesel demand may be replaced with the bio methane in the United States. So both the countries can diversify their energy sources.	(Pasqual et al., 2018)
Sweden	Mitigation	The main purpose of the study is to evaluate the climate mitigation effectiveness of ever increasing use of bio based construction materials in building of new residencies in Sweden for future requirements and technological changes.	The findings show that an escalated use of wood products to mitigate the climate impacts in all the scenarios was critically evaluated. The use of harvested wood products results to lower climate impacts in all scenarios. If the low impact materials are used to construct the dwellings in Sweden it would be effective to mitigate the climate change affects. The construction sector of Sweden can attain the maximum climate change mitigation scenarios by implementing the low-impact building typologies for the Swedish dewellers.	(Peñaloza et al., 2018)

towards the alarming situation (Benhelal et al., 2013).

In Pakistan, like many other developing countries, the amount of vehicles used is rising according to the respective shares of urban and rural areas which are causing higher emissions. The EDGAR data revealed that there is a staggering 139% increment in road transportation emissions from 12,890 Gg (Giga tons) to 30,935 Gg (Ul-Haq et al., 2017). Similar to other countries, in Pakistan, the increase in number of vehicles have led to increased CO_2 emissions, but the most important and noticeable concern here is that, the vehicular emission rate in Pakistan has reported to be extremely higher as compared to the United States (Shah and Zeeshan, 2016). Reasons for such a condition may include older vehicles, lack of emission control provisions, lack of efficient vehicle engines, poor fuel utilization, reduced overall performance of transport system, and diesel usage as primary fuel (Shabbir and Ahmad, 2010). Engine adjustments and settings were shown to impact the fuel efficiency significantly. Smart and efficient engine adjustments can minimize the fuel consumptions as well as CO_2 emissions (Prinz et al., 2018). In rural, peri-urban areas and even in small cities, all of the mentioned factors have been in worst condition as compare to urban areas due to lack of importance and implementation of rules and regulations, as mentioned in previous studies the reason that in practice most focus on large areas (Karner, 2016). Albeit, the amount of vehicles in rural areas are smaller in number, but their share of generated emissions per vehicle is much higher than share of emissions generated in urban areas with higher amount of vehicles. The government doesn't take any action in these areas even though the transportation infrastructure is present but the predicament is the state of vehicles and their performance, like in china the overall direct per capita CO_2 emissions of urban inhabitants were more than those of rural inhabitants, but this gap was narrowing. The direct per capita CO_2 emissions of urban inhabitants were 42% higher than those of non-urban in 2005 and were 15% higher in 2012 (Mi et al., 2017).

While transportation seemed to be the major issue in climate change, industrialization also plays a key role in causing climate change. According to our findings, industrialization was one of the major contributors in climate change with a marginal difference to transportation and in specific regions and areas; it had the highest share in climate change concerns. Emissions in progression of greenhouse gases (GHGs) due to extended industrial operations has touched an alarming level and is expected to be manifolds even at a faster pace (Benhelal et al., 2013). The EDGAR data revealed that there is a staggering 169% increment in manufacturing industries and factories emissions from 17,098 Gg to 46,122 Gg (EDGAR, 2009). Industries in Pakistan affect the climate more harmfully as compared to other developed countries because many industries are located within the city range and they discharge their waste directly into the water and also cause aerial pollution without undertaking any environment safety measures (Table S6). The pharmaceutical industries discharge their untreated waste in sewage that can be detected into waste water, soil and plants (Hussain et al., 2016). The cities of Lahore, Karachi and Faisalabad, the most developed cities of Pakistan, housed huge number manufacturing factories in the heart of the cities and these factories were situated next to the residential areas and caused hazardous influence to the atmosphere. This example is just an indicator of industrialization impact on urban developed cities, whereas the rural communities suffer significant impact of industrial pollution even monetarily (Antoci et al., 2018) there is less number of industries in rural areas and smaller cities but the conditions are much worse due to extreme ignorance of rules and regulations and unplanned

industrial expansion (Yousaf et al., 2016). Improvements and efficient up gradations of vital industrial structure can bag the success for hazardous emissions only in strict legal environment (Wang et al., 2018). In the other way, the embodied GHG emissions caused by production, maintenance, construction, replacement and demolition activities are getting significance (Mamo et al., 2018).

The impact of urbanization is almost similar to that of industrialization, according to the findings of the study, urbanization also has significant impact on climate change in Pakistan where in very few regions and areas, urbanization's impact has been marginally higher or equal to that of industrialization. Due to expansion in population size, Pakistan is rapidly urbanizing and it is estimated that by 2050, 63.66% of the people will be living in cities, compared to 30.58% in 1990 (Tahir et al., 2010). With the rise in rapid urbanization, the emissions responsible for climate change due to urbanization are also on the rise. Moreover, the urban environment is more threatened by the likely to be happened incidents caused by the climate extremes such as the heat waves and anthropogenic climate factors (Imran et al., 2018). A long history of unplanned development not only have had negative impacts on Pakistan's socio-economic fabric but also on its environment, particularly in urban areas (Nadeem and Hameed, 2008), which is aligned with the study as can be seen in Table S6. Prompt urbanization has been seen for the study area as causing one of the largest anthropogenic emissions of CO_2 among others. According to the EDGAR data, baring forests, cement manufacturing, traffic, energy production, industrial manufacturing and construction were identified as foremost anthropogenic reasons of CO_2 emissions during 1990–2008 in Pakistan (Ul-Haq et al., 2017). The rise in emissions causing climate change due to urbanization can also be attributed to automobiles (Andreae and Merlet, 2001), industrial activities (Irfan et al., 2014), electricity generation (van der Werf et al., 2004), and alteration in land such as deforestation and urbanization in the area (Houghton, 2003).

The effects of waste and agriculture on climate change have been of almost similar magnitude in Pakistan and in most regions, these two factors are marginally undistinguishable to each other. Waste disposal and treatment is an important potential source of GHG emissions (Khan et al., 2011) but because of an immense rise in urbanization, city municipal organizations are incapable of managing this substantial increase causing poor utilities (Jibran et al., 2015). According to the findings of the study, waste stands at the fourth highest shareholder in impacting climate change in Pakistan, which is parallel to previous studies which states that municipal solid waste (MSW) sector ranked fourth in sharing towards global emissions of non- CO_2 GHGs that contributes to global warming and climate change (Matthews and Themelis, 2007). According to an estimate, only 50–69% of the waste generated in Pakistan is not managed properly from pickup to send out in open areas to landfills for disposal outside the city limits, that chalks up to 67,500 tons of solid waste produced in Pakistan on daily basis whereas the remaining of the garbage is left on roadsides and any inhabited location (Pak-EPA, 2005). In rural areas and smaller cities, the condition is more concerning with waste not being disposed at all in many areas, as mentioned in previous studies, mostly in rural areas of developing countries slight attention paying to internal waste (Han et al., 2017), while urban developed cities like Karachi, the condition is absolutely distressing with piles of waste spread across streets and alleys.

In addition of waste, agriculture has also been one of the important influencers on climate change in Pakistan as Pakistan is known as an agricultural country and takes pride in harvesting all kinds of crops but waste from burning agriculture is one of the main reason of CO_2 emissions in the area. Each year, around 7–10 hector tons of biomass is produced through rice and wheat crops (Mandal et al., 2004), as agriculture occupies a lion's share in Pakistan's economy, the increased use of pesticides is also harming the atmosphere and affecting climate change (Table S6). This change is going to affect the indigenous communities which are wholly dependent on agricultural livelihoods. In this context, the indigenous communities have already been conveyed and acknowledged in the pretext of this climate change monster (Makondo and Thomas, 2018). Likewise to agriculture, emissions from livestock activity has also been known to the most important contributor to climate change in the sector of agriculture (Cecchini et al., 2018), through livestock manure and enteric fermentation, however forestry contributes in climate change through the threat of deforestation (Table S6). Deforestation spreads across through development expansion, the use of traditional farming methods, overgrazing, bushfires and timber exploitation (Cobbinah and Anane, 2016). The distressing rate of deforestation can be linked to low utilization of environment-friendly renewable energy resources which leads to a higher rate of environment deterioration. The statistical analysis revealed an opposite picture, with agriculture being non-significant (Table 2). The reasons could include lack of knowledge and awareness within the people in everyday life.

In Pakistan, energy sector is also contributing towards climate change, according to the findings, the energy utilized in most regions is developed through environment-degrading resources (Table S6). Use of conventional and orthodox energy resources that harm the environment is causing sharp rise in temperature and precipitation throughout SAARC region (Imran et al., 2016). At present, in most developing countries, a variety of fossil energy sources are being used to generate agricultural productions, which usually cause to air, water, and soil pollution (Taki et al., 2018). Mostly in developing countries about 60% of inhabitant consumed energy is produced from solid fuels such as coal and biomass (Malla and Timilsina, 2014). Around 2.4 billion people depend upon traditional biomass (charcoal, agricultural residues, manure and fuel wood)as their main source of energy for the accomplishment of their basic needs such as lighting, cooking and heating (Liu et al., 2017). A lot of research studies indicate that region wise technological advancements, economic progress and resources endowment and such other factors has close association with CO2 emissions (Guo et al., 2015). According to our survey findings the conditions in rural areas and smaller cities is much more concerning because many of these areas inhabitant still uses traditional biomass (Table S6). CART approach was applied, to elaborate the most significant factors, the descriptive relationship between them and for interpretation of data in a most simplified way to the persons, unfamiliar with statistics (Fig. S2).

These all above mentioned sectors are the major contributors in climate change in Pakistan which causes severe impacts, namely: temperature rise, drought, pest-diseases, health issues, seasonal change, and lifestyle change (Fig. 10). The results align perfectly with the previously conducted studies, as Pakistan has been facing extreme climate happenings such as change in temperature, lack of water resources, droughts, floods and rise in pest-diseases (Smit and Skinner, 2002) which is evident from the drought from 1999 to 2003 and continuous floods of 2010, 2011, 2012 and 2014 (Abid et al., 2016) Rising of sea level, severity in earth's temperature, atmospheric changes and considerable change in rainfall's quantity are the results of climate change (Kayani et al., 2018). Moreover, factors like dust storms, speedy melting of glaciers and thunderstorms are also the added adversaries (Awais et al., 2018). The impacts of climate change can be seen degrading the environment at an exponential rate and climate change impacts are a disturbing indication that the situation is worsening. Climate change, in addition with other environmental changes, is now causing catastrophic changes in the Earth system, Ecological system including

changes in ice cover, sea level, species extinctions, and extreme events (Aguiar et al., 2018).

The study indicates that over three-fourth of the country believes that there is distinctive change in weather pattern over the years and the majority of them came from Punjab region followed by Sindh region and area-wise the majority was from urban areas (Fig. 7). In whole Pakistan, majority of the sample identified that climate change is extremely important and about one-fourth of them showed that climate change is quite important. The results from all of the provinces (Punjab, Sindh, KPK & FATA, Baluchistan, Gilgit-B &AK and Islamabad) and the areas (urban, rural and peri-urban) concluded similar results as whole Pakistan (Fig. 8). As mentioned above, the impacts of the climate change are extremely severe and are increasing gradually, the importance of climate change should be stressed upon to greater extents, effective remedial actions such as mitigation and adaptation are necessary as these techniques are used globally to tackle this issue (Table 3) and implementation of appropriate environmental policies is immediately required.

5. Conclusion

This is an empirical research study on climate change in Pakistan as climate change is a growing concern for all the countries around the world particularly South Asian countries. South Asian region has low adaptive and mitigate capacity due to high level of poverty, lack of financial and physical resources. Since Pakistan is a South Asian country, a thorough research can pave way for extensive studies to be conducted not only in South Asian countries but also in developed countries. This study provides a rich understanding of climate change, a solid foundation on the reasons of change in climate, the key sectors in contributing towards climate change, the ranking of key concerning sectors to climate change, the impacts of climate change, importance of climate issue, responsible institutions of treating climate change and the change in weather pattern due to climate change in Pakistan. This field-based study conducted a questionnaire survey to improve our understanding and to determine the most concerning sectors to climate were transportation, at the most, followed by industrialization and urbanization, whereas waste, energy usage and agriculture also had significant impact on the climate. Since climate change has a substantial relationship with all the above mentioned sectors, a proper and effective management of these sectors is required to not only improve the environment through reduced emissions but also to support economic sector of Pakistan. The study determines that all the areas of Pakistan play a crucial role in broadening development context of Pakistan, whereas it explicitly emphasizes the role of rural and peri-urban areas in affecting climate in the above mentioned sectors.

From the research, we can conclude that there is an immediate and strong need to spread awareness, knowledge and information among the people from grassroots-level. As the degradation of environment continues, we can suggest that effective solutions like mitigation and adaptation are of paramount importance and governmental policies that can increase awareness among people and reduce the effects of climate change are in need of implementation. We also suggest that only through a combined effort of government officials, policymakers, philanthropists and individuals the effects of climate change can be reverted, deterioration of the environment can be reduced and restore the environment to an improved state for our next generations. It is highly recommended that such kind of research studies should be carried out across the world and especially in the developing counties as they are on the verge of climate victimization more than the developed countries. This will enable them to be vocal on international forums about their rights and climate change vulnerabilities. This would also facilitate them to formulate comprehensive strategy to mitigate the climate affects and to adopt the measures to avoid the threats sooner or later they are going to face.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jclepro.2018.07.272.

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